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How does a newly encountered face become familiar? The effect of within-person variability on adults' and children's perception of identity

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ABSTRACT

Adults and children aged 6 years and older easily recognize multiple images of a familiar face, but often perceive two images of an unfamiliar face as belonging to different identities. Here we examined the process by which a newly encountered face becomes familiar, defined as accurate recognition of multiple images that capture natural within-person variability in appearance. In Experiment 1 we examined whether exposure to within-person variability in appearance helps children learn a new face. Children aged 6–13 years watched a 10-min video of a woman reading a story; she was filmed on a single day (low variability) or over three days, across which her appearance and filming conditions (e.g., camera, lighting) varied (high variability). After familiarization, participants sorted a set of images comprising novel images of the target identity intermixed with distractors. Compared to participants who received no familiarization, children showed evidence of learning only in the high-variability condition, in contrast to adults who showed evidence of learning in both the low- and high-variability conditions. Experiment 2 highlighted the efficiency with which adults learn a new face; their accuracy was comparable across training conditions despite variability in duration (1 vs. 10 min) and type (video vs. static images) of training. Collectively, our findings show that exposure to variability leads to the formation of a robust representation of facial identity, consistent with perceptual learning in other domains (e.g., language), and that the development of face learning is protracted throughout childhood. We discuss possible underlying mechanisms.

1. Introduction

Two pictures of the same person can look very different and pictures of two different people can look very similar. Thus, accurate person recognition requires both discrimination (telling people apart) and identity matching (recognizing a person when his/her appearance changes). Despite over 30 years of psychological research aimed at understanding face recognition, it is only relatively recently that the challenge of recognizing identity despite within-person variability in appearance (resulting from changes in hairstyle, make-up, lighting, point of view, camera angle/distance) has been brought to the forefront of face recognition research (Burton, 2013). This has allowed parallels to be drawn between faces and other domains (e.g., language [see Watson, Robbins, & Best, 2014]) in which understanding within-exemplar variability has received attention. In addition to its broad theoretical implications, understanding face recognition across changes in appearance represents a challenge faced in daily interactions (e.g., for recognizing our colleague when he shaves his beard), in the security industry (e.g., for determining whether the identity in a photograph matches that of the person holding the passport) and in eyewitness testimony (e.g., for recognizing someone we saw commit a crime in a photo line-up).

Understanding the effects of within-person variability on identity perception is central to understanding the difference between familiar and unfamiliar face recognition. We can easily recognize hundreds of images of famous people or those with whom we are personally familiar. In contrast, even a small change in appearance can impair our recognition of unfamiliar faces. For example, accuracy in a 1-in-10 task, in which sample and target photos were taken with different cameras, was only 70% despite the photos being taken on the same day, from the same viewing angle, and with a neutral expression (Bruce et al., 1999; Megreya & Bindemann, 2015).

A seminal paper by Jenkins and colleagues most clearly demonstrated how familiarity influences recognition of identity

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in ambient images (Jenkins, White, Van Montfort, & Burton, 2011). Participants were asked to sort a stack of 40 photographs (20 photos of two identities) into piles such that each pile contained all of the images of a single identity; participants were not informed about the number of identities present. When the identities were familiar, participants performed without error (i.e., they accurately perceived that only two identities were present). In contrast, when the identities were unfamiliar, participants perceived an average of six different identities. The impact of familiarity is even stronger for other-race faces: Although adults make twice as many piles when sorting unfamiliar other-race faces than when sorting unfamiliar own-race faces, the own-race advantage is eliminated (i.e., performance is perfect) when sorting familiar faces (Zhou & Mondloch, 2016). These results are attributable to familiar faces having a sufficiently robust representation to allow recognition across a range of inputs; recognition of unfamiliar faces relies more on lower-level image properties and is heavily tied to a specific instance (see Burton, Jenkins, Hancock, & White, 2005; Burton, Jenkins, & Schweinberger, 2011; Hancock, Bruce, & Burton, 2000; Jenkins et al., 2011; Johnston & Edmonds, 2009).

A current hot topic in the field of face recognition, then, is how does recognition of a newly encountered face make the transition from image dependent (unfamiliar) to robust (familiar)? Recent evidence from adult participants suggests that exposure to the way in which a particular face varies is key to the formation of a robust representation of that face (Andrews, Jenkins, Cursiter, & Burton, 2015; Bindemann & Sandford, 2011; Dowsett, Sandford, & Burton, 2016; Menon, White, & Kemp, 2015b; Ritchie & Burton, 2017). Menon, White, & Kemp (2015a) showed participants a pair of images. Participants were told that the two sample images either belonged to two different people or (correctly) to the same person. The task was to decide whether a third image matched the identity of one (2-person condition) or both (1-person condition) sample images. Accuracy was higher in the 1-person condition, suggesting that knowing how a face can vary in appearance facilitates recognition of a new instance. Likewise, recognizing new images of learned identities is more accurate after studying 10 images with high variability in appearance than after studying 10 images with low variability in appearance (Ritchie & Burton) and finding a target identity in a 30-image lineup becomes easier if the to-be-matched sample comprises six images rather than a single image (Dowsett et al.). Collectively, these studies show that as new instances are encountered a robust representation develops. The more variability incorporated in a representation, the greater the likelihood that a novel instance will be recognized (Burton, Kramer, Ritchie, & Jenkins, 2016). That variability is a route to learning is consistent with variability leading to optimal training of perceptual expertise in other domains (for detecting dangerous items in luggage, Gonzalez & Madhavan, 2011; texture discrimination, Hussain, Bennett, & Sekuler, 2012).

1.1. The development of face recognition

Numerous studies have investigated the development of expert face recognition and its underlying mechanisms. These studies have greatly advanced our understanding of how children discriminate faces (tell people apart): They present children with identical (e.g., Baudouin, Gallay, Durand, & Robichon, 2010; Gilchrist & McKone, 2003; Macchi Cassia, Luo, Pisacane, Li, & Lee, 2014; McKone & Boyer, 2006; Mondloch, Le Grand, & Maurer, 2002; Mondloch & Thomson, 2008; Pellicano & Rhodes, 2003; Pellicano, Rhodes, & Peters, 2006; Tanaka, Kay, Grinnell, Stansfield, & Szechter, 1998) or nearly identical (Bruce et al., 2000; Megreya & Bindemann, 2015; Mondloch, Geldart, Maurer, & Le Grand, 2003) images of unfamiliar faces at study and test. The same is true of the few studies that have examined children's ability to recognize personally familiar faces (Bonner & Burton, 2004; Ge et al., 2009; Mondloch & Thomson, 2008; Newcombe & Lie, 1995; Wilson, Blades, Coleman, & Pascalis, 2009). Very little is known about the development of the other central component of face recognition: Children's ability to recognize identity in images that capture natural variability in appearance and the process by which faces become familiar during childhood.

Laurence and Mondloch (2016) adapted Jenkins et al.'s (2011) protocol to provide the first examination of children's ability to recognize a face's identity across a set of images that incorporate natural variability. They presented children with a toy house on which a single photo of a target identity was mounted. That identity was either highly familiar (the child's own teacher) or wholly unfamiliar (a teacher from a different school). Children were provided with a stack of photographs that included nine novel images of the target identity and nine different images of a similar-looking distractor (plus control stimuli). These images were presented sequentially to children, who were asked to place all of the images of the target into the house but to keep everyone else out. When tested with an unfamiliar identity, performance improved between 5 and 12 years of age. When tested with a familiar identity (i.e., their own teacher), children aged 6 years and older performed (nearly) without error; however, several 4- and 5 -year-olds made multiple errors despite knowing their teacher for several months. These results suggest that by age 6 years children, like adults, are able to build robust representations of identity that allow recognition even when viewing never-before-seen images, at least for identities with long-standing representations (Burton et al., 2005, 2011). However, children knew their teacher for a minimum of 3 and as many as 9 months, and so what remains unknown is the process by which a face becomes familiar during childhood and whether the ability to use variability in appearance to form a representation changes between 6 and 12 years of age. Given that exposure to variability facilitates learning in other domains early in development (e.g., early word learning; Rost & McMurray, 2009; Singh, 2008), and exposure to within-person variability in appearance facilitates adults' face learning (see Burton et al., 2016 for a discussion), systematically varying the amount of variability to which children are exposed might influence their ability to build a robust representation of a newly encountered face.

Here we directly investigated the contribution of exposure to variability in appearance by familiarizing children aged 6–13 years with a target identity, an age range over which the ability to recognize an unfamiliar identity despite variability in appearance continues to improve (Laurence & Mondloch, 2016). We endeavoured to maximize children's opportunity to learn by presenting each child with a 10-min video in which one of three target identities read a children's storybook. Each of the three models was filmed reading the identical story on three separate days and across days we altered the target's appearance (hair, make-up), lighting, and the camera used for recording. Each child watched the video of one target. We manipulated variability by presenting the video as it was filmed on a single day (low-variability condition) or as it was filmed across the three days (high-variability condition), which we did by splicing each video into three segments and creating various combinations. Children in a no-training control group did not watch the video. After watching the video (or not) all children completed the sorting task designed by Laurence and Mondloch. We hypothesized that performance would increase with age and that children in the training conditions would perform more accurately than children in the no-training control group. Most notably we predicted that children in the low-variability condition would show a reduced benefit of training, consistent with evidence from adults that exposure to higher variability enhances learning (see above). We also hypothesized that